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Based Kinect application to promote Mixtec culture

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Abstract

Statistics show that attendance to culture and science promotion centers can be increased if interactive activities are offered. This paper presents the development of an application based on Kinect SDK which manipulates 3D models of archaeological pieces from the Museo Regional de Huajuapan (MureH). This manipulation is performed without controls, with only hand movements needed to interact with the application. The process and details of 3D models design highlighting the use of textures to add a more realistic appearance is presented, along with some details and tests about the development of the Kinect-based Application.

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Keywords: edutainment, augmented reality, virtual reality, 3D model

1. Introduction

In 2012 there were 1,183 museums registered in Mexico, among which the state of Oaxaca has 43 [1]. According to the yearbook of State statistics, published in 2010 by the INEGI [2], there were a number of 44,914,738 visitors nationwide. Of this, in the state of Oaxaca, within the various cultural activities museums visits recorded a percentage of 9.2[3]. These numbers are very poor considering that Mexico has a rich and varied cultural heritage.

Conversely, the experience in interactive museums such as the "Papalote" in Mexico city shows a completely different view, taking into account the fact that in 2008 it had 2,404,776 visitors representing just over 5% of the total of visits nationwide. This shows us that interactive museums are more attractive to the general population [4].

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It can be said that museums are a vital component for the dissemination and development of the cultural identity of a country. In the city of Huajuapan there is a museum known as the MureH, that exhibits some pieces from the region, including the archaeological site of the "Cerro de las Minas". This museum also provides a forum for artistic and cultural events, which makes it one of the main showpieces of Mixteca culture. However, statistics show a low number of visitors making it difficult to spread the culture among the population.

With the rise of Kinect, there has been a change in the way of conceiving video games. This has proved useful in the implementation of interactive applications where the user has contact with a virtual world through cameras and sensors for skeleton tracking. To build applications with this technology, Microsoft provides a non-commercial license for research[1], testing, and experimentation for the beta version or a commercial license which authorizes the development and distribution of commercial applications. The other option is the use of the multiplataform open source development kit named OpenNI[2].

Our research group made the decision to create an interactive, multimedia and Kinect based application to enhance the people's interest in the museum exhibitions.

The remainder of the paper is organized as follows: In section two important works and concepts related to augmented reality and Kinect technology are presented; in section three, important aspects of the 3D modeling process of the archaeological pieces are described, in order to embed them into a Kinect application to implement augmented reality. Finally, we report our conclusions and propose some future work.

2. Related work

In this section we briefly present some of the research literature related to Augmented Reality (AR), skeleton tracking using Kinect. We present an explanation of AR and its use in the museums. We also review the most recurrent applications of the Kinect technology as well as its use in the museum.

2.1. Augmented Reality

AR is a Virtual Reality (VR) technology that allows one to add virtual objects inside computer simulated reality, with the power to manipulate such objects as if they were real. Usually such objects consist of 3D models even though that is not a requisite [5, 6]. In other words, AR is a mixture of real images captured by a camera and computer generated images. In contrast with VR, AR allows the user to manipulate virtual objects as if they were real [7] manually, without the use of devices like a mouse.

AR is already having a great impact in variety of areas such as marketing, design, entertainment (video games), education and culture among others. Companies like Mercedes Benz[3], Colgate[4], Volkswagen[5], Starbucks[6] and Adidas[7] are making use of AR to increase interest in their products. We therefore see a global trend that can also be applied to museums. Here, AR is being used innovatively as part of a museum's resources by the achievement or more user friendly interaction between visitors and the exhibition pieces. An example of this can be seen in the Allard Pierson museum of Amsterdam[8] with 2 applications: the Roman Forum and Satricum.

Another way to apply AR is by using geo-location, as has been implemented in some museums to present information about historical sites [9].

Recently in Mexico, CONACULTA is developing a project, which seeks to promote a network of digital museums [10], which can include applications such as tours of 360 degrees, third dimension and AR among others. Museums that are within the project and working with AR are the House of Carranza Museum [11] and the Popular Cultures Museum [12].However, in these museums AR is incorporated through a device with a camera and a printed mark, to allow users to interact through their web page.

[1] http://www.microsoft.com/en-us/kinectforwindows/
[2] http://www.openni.org/
[3] http://www.vuelodigital.com/2012/01/05/mercedes-benz-usa-la-realidad-aumentada-como-punto-de-venta/
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2.2. Kinect

Kinect technology is already being used for different purposes among which we can find indoor positioning systems, novel user interfaces and gesture recognition. Applications in medicine, ubiquitous computing, augmented reality, training performance evaluation, and many more are being developed.

A system for physical rehabilitation constructed using video games technology [13] is using Kinect to help evaluate people with neurological diseases and the effectiveness of their therapy. A similar approach using pattern recognition in their video sequences is used to compare inexperienced dancers performance with that of a professional dancer [14].

Gesture recognition through Kinect technology is being used to develop novel user interfaces where other technologies are inappropriate. Kinect, for use -in the kitchen- runs tests with a camera based interface to control a virtual panel using buttons with push gesture recognition. Users can surf a recipe book, set up a timer and control a music player. Another system uses a Kinect based interface to command an interactive multimedia application [15].

Indoor positioning systems have evolved to use Kinect, in conjunction with smartphones, to implement ubiquitous computing. A set of virtual sensors can be built to process data from Kinect and a smartphone as shown in [16]. This is a support for rapid prototyping.

An AR system built using Kinect is in the “El Papalote” museum in Mexico City [17]. This application shows the liver function to children and shows them how to take care of their health. Skeleton tracking using OpenNI and Unity APIs were used to build the system.

Interactive applications are well suited to museums because people feel more interested in the exhibitions and they will experience increased curiosity, resulting in learning more by searching for more information. Augmented Reality allows users to interact with virtual objects and play with them, and skeleton tracking can be used to allow a user to manipulate objects, just by moving without touching anything. Microsoft Kinect SDK and OpenNI APIs are used to develop applications to manipulate Kinect data in C++ and C#.

Based on the above, our research group has entered into an agreement with the MureH to develop applications that make use of new technologies such as AR and Kinect.

3. Methodology

3.1. Diagnostics

MureH receives about five hundred visitors each month. The main visitors are students, people who live nearby the Mixteca in Oaxaca state and even includes people from other countries. Visitors include about six basic or secondary school groups a month of an average of 30 students.

Museum cost is nonprofit - free on sundays - because of the desire to promote frequent visits from the local and foreign population. The average number of visits per day is 6 students, a very low amount for a state with such a rich culture. This project is expected to improve the flow to the museum, arousing increased interest through an interactive system based on Kinect technology.

3.2. Analysis and selection of 3D modeling tools

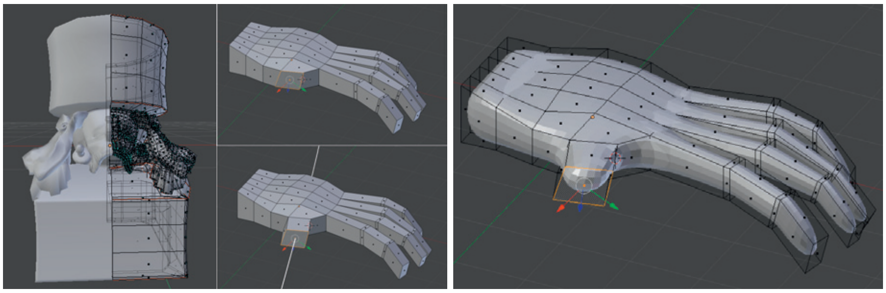
Kinect SDK loads 3D models directly in DirectX format (.x files). The research group evaluated four 3D modelling tools: Blender [18] AutoDesk 3Ds Max [19], AutoDesk Maya [20] and SketchUp [21].

Autodesk 3ds Max and *Autodesk Maya* can be purchased for a price of about 224.20 euros. Neither of these options require plugins for exporting directly to DirectX format - the format required by the Kinect SDK API - to avoid problems in the use of textures, this is important to give realistic appearance to pieces. SketchUp has great user support and development by Google. It is free, but it has no option to export directly to DirectX, although this problem can be overcome by use of additional programs.

Although Blender is a less user friendly 3D modeling tool, there is extensive user support and referrals, it is free, multiplataform, robust, and can export directly to DirectX format. The selected 3D modeling tool was therefore Blender because it presented most benefits.

3.3. 3D modeling process

While performing 3D modeling, several techniques have to be used [22, 23, 24]. Typically, the first step is to add a *predefined basic structure* such as a cube or plane. After that, the set of modifications commonly applied are: *polygon mesh modeling* that can be used to add, remove or modify sections of the mesh; *extrude modeling* that can be used to expand or contract replicas of sets of points, lines or planes (see Fig. 1(b)); *mirror modifier* that can be used to model symmetrical objects based on a reference axis or object by mirroring the modifications to the mesh (see Fig. 1(a)); *subdivision surface modifier* which gives a more organic appearance to the final models (see Fig. 1(c)). After completing this process, the model has default material assigned such as shown in Fig. 1. *Texture modelling* allows one to add more realistic visual details to the 3D models in order to avoid a more detailed mesh edition. After this, textures are applied using the *UV Mapping tool*.



(a) Mirror modifier (b) Extrude modeling (c) Subdivision modifier

Fig. 1. Some 3D modeling steps

UV maps allow unwrapping of any 3D mesh to transform it to a 2D plane. Seams need to be created to unwrap the 3D mesh (see red edges in the 3D model of Fig. 1(a)). Seams are generally created on the edges of the 3D object and are used to separate a number of polygons in relation to its neighbours int order to create non-overlapping views of the mesh to facilitate the application of textures.

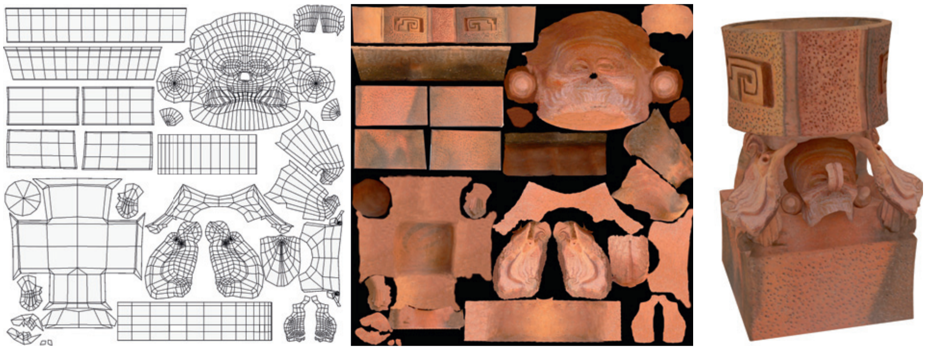
The *UV Mapping* tool generates a map of different regions separated by the seams (UV Map) (see Fig. 2(a)), which can be viewed in the *UV/Image Editor* view in Blender. If necessary, a region of a the UV Map can be zoomed in - using the scale and transformation options to rearrange the rest of the mesh - to show a more detailed region in the final model.

The models were created from pictures taken of the pieces, and included at least 5 views: front, back, left side, right side, top, bottom and in some cases a view of important details. These are used to make a 2D projection of the 3D wrap of every piece.

Regions of the pictures are mapped into the UV map using tools like Photoshop or Gimp. These can be used together to complete he most tasks during editing the textured UV map. Main tasks done during the image editing are: color adjustments, to match colors of different regions mainly caused by lighting conditions; cloning regions of images to remove stains or match colors in neighbour regions; use of layers to permit the edition of different parts of the images independently, and transform operations to match the form of the textures to the regions defined by the UV map tool.

The clone tool in Blender can be used in *Texture Paint Mode* to match the appearance in regions divided by the seams. It works by selecting a clone point and copying this region where required. The main tool options used are the radius and the strength of the clone brush. The resulting UV Map, Fig. 2(b) is the result of editing the texture map using the external image editor and the clone tool of Blender. A render of the model is shown in Fig. 2(c).

Applying textures to the models results in more realistic 3D pieces. In some cases there was the ability to reconstruct the piece and in other cases the original texture was preserved to improve altering the information about the presented archaeological piece.



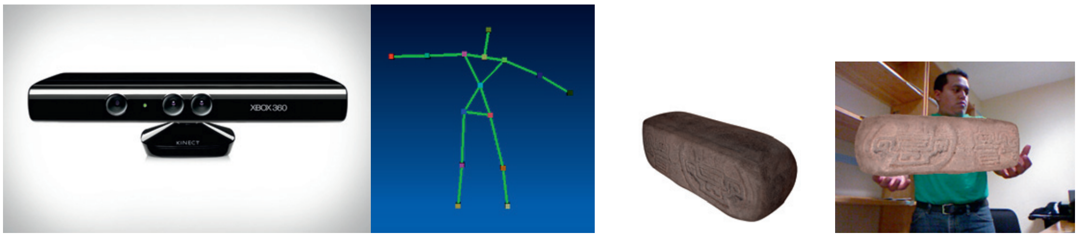
(a) UV Map generated in Blender (b) UV Map with textures (c) Textures applied

Fig. 2. Different steps of texture images edition and its application to the model of Fig. 1(a)

At this stage, the developing team has created a total of 22 3D models of selected archaeological pieces. The selection of these pieces was made by experts in the area (INAH, Instituto Nacional de Antropología e Historia, National Institute of Anthropology and History) and the MureH patronage .Their criteria was the cultural importance and preservation status of the pieces.

3.4. Kinect and AR

After attaining realistic 3D models of the archeological pieces (see Fig. 3(c)), it is necessary to interact with them (see Fig. 3(b)). This interaction must be natural to the user. Taking advantage of Kinect capacities, it is possible to achieve that interaction manually, without the use of a keyboard, mouse or any other physical device. By mixing Kinect's camera images (see Fig. 3(a)) with models we are finally able to get AR(see Fig. 3(d)).



(a) Kinect (b) Skeleton tracking (c) 3D Model (d) Augmented Reality

Fig. 3. Items for building an AR application

To make the application more user friendly, we have created an interactive menu, the menu elements will appear in fixed positions to make them easily manipulated. They are also highlighted in the image so the user can quickly find them.

At present, selected options are detected by using skeleton tracking. When the user's right hand coordinates are located in the icon area range it then triggers a push action on that icon. At this moment it is enough 'to touch' the icons and immediately new options will appear. In the near future, gesture recognition techniques will be applied to enhance the interface's behavior and prevent false push actions. Implemented options allow the user to zoom in, zoom out, and move objects in X, Y and Z coordinates.

These menus can manipulate virtual archaeological pieces: zoom, scroll in *X*, *Y* and *Z*, in order to select an option. The user simply moves his/her hand over the icon (see Fig. 4(a)) and automatically this will show a new menu (see Fig. 4(b)).

(a) Zoom choice (b) Zoom options

Fig. 4. Interative menu

By zooming in, the user can appreciate details in the objects. Selecting this option(see Fig. 5(a)) will magnify the objects and the decorations in the archeological pieces will be clear. Zooming out (see Fig. 3.4) will have the opposite effect.

(a) Zoom in option (b) Zoomed in model

Fig. 5. Zoom in

When the user moves his/her hand over the 'zoom out' option (see Fig. 6(a)), the virtual part will become smaller (see Fig. 6(b)).

(a) Zoom out (b) Zoomed out model

Fig. 6. Zoom out

4. Conclusions and Future work

4.1. Conclusions

A Kinect based system can load 3D models and through the use of skeleton tracking libraries we can generate AR in real time. All this allows to have a more interactive user experience.

The main contribution of the paper is to eliminate the use of marks to generate AR by the use of skeleton tracking and the use of 3D techniques to model archeological pieces to spread the cultural heritage of the Mixtecas. The aim is also to apply leading edge technology to develop attractive user interfaces and interactive multimedia exhibitions. Skeleton tracking allows a more natural interaction with virtual objects.

We tested our application performance with 10 people of different statures and body types in scenarios of 4x4m. The results indicated that a minimum distance between the Kinect and the user of at least 3 meters is necessary and the area must be free of obstacles so that the Kinect can detect the entire skeleton, otherwise it may give misinformation about the position of the joints, which leads to inaccurate results while selecting the menus.

When we take into account the restrictions mentioned above results were satisfactory and the users found the use of the application very insightful.

4.2. Future work

Future work involves enhancing the user interface to present a more functional design. This will be done by running tests before and after their installation in the museum facilities to evaluate performance, as well as usability tests with information collected from real users.

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